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A Study of the Temporal Changes in the Organization of Retention

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INTRODUCTION

One aspect of the study of retention which produces controversial findings is the temporal change (s) in the organization of recall. Among the difficulties in this area of investigation is the definition of the term organization. As it will be used here, organization means the occurrence of clusters of related words in recall. While this definition is not the only one which may be employed, it has the advantage that one can analyze the occurrence of clusters in retention by the method developed by Bousfield (1). Clustering is defined by Bousfield as ". . . the occurrence of related words as they appear in the recall of items presented for learning in random order" (2). The present study is primarily concerned with the application of Bousfield's method to the question of whether or not there are changes in the organization of the recall of words over successive retention tests.

Of the variety of theories of retention, three have something explicit to say about changes in the organization of retention over time. The Gestalt theory of memory (3), Bartlett's theory of remembering (4) and Hebb's theory of memory (5) state, in general, that saliences set up during an original perception (of visual forms, verbal associates or prose passages) persist in time, and that these saliences will produce regular changes in the organization of recall. The theoretical issue among these theories is whether the changes in retention are due to spontaneous changes in the memory traces, or alternatively, whether the changes in retention are due to structural changes in the nerve-connections built up in learning. Hebb's view is that changes in retention, other than the loss of material through disuse, are due to new learning. In contrast to these theories, the interference theory (6), the disuse theory (7), Freudian-repression theory (8), and the pleasant-unpleasant theory (9) say nothing about changes in the organization of recall. These latter theories are only concerned with decrements in retention. Some workers, for example Saul and Osgood (10), have pitted interference theory against Gestalt theory as the alternative views about changes in the organization of retention over time. Since interference theory says nothing about changes in the organization of recall, it seems futile to seek alternative explanations of Gestalt theory by theories which do not deal with the same class of observations. It is not inconceivable that decrements in the amount of material retained and changes in the organization of the material retained both occur. While the former has a firmer experimental status as a mnemonic effect, it does not preclude the latter. The empirical question is whether changes in organization of retained material occur over time.¹

There are several methodological problems in the investigation of changes in the organization of retention over time (11,12,13). One problem has been attributed to the use of successive retention tests. It is generally asserted that use of successive retention tests introduces a practice effect, and thereby increases the probability of organization, and changes in organization. There are a number of difficulties with this criticism. Practice is usually thought to influence the amount of material retained over time. If practice also influences the organization of the material retained, then the effect of practice on organization should be systematically investigated. Hebb seems to be the only one who says explicitly that practice affects the organization of the memory traces. One might suggest that practice reduces the probability of organization because with practice one is likely to recall more material. But, with more material recalled, the possible number of different associations is greater. Consequently, the less likely it is that any one organization will prevail. If one finds, however, that with successive retention tests, that less material is lost, and that there are changes in the organization of the material, a possible explanation is that the organization of the material is holding up the losses one usually finds over time¹. The more likely alternative, however, can only be decided by empirical work.

Another problem is the measurement of organization itself, and the changes in organization of the responses of the subjects. Previously, the kinds of stimulus material used have been visual forms, lists of words (real and nonsense), numbers and stories. The main difficulty with visual forms is that there is no method for quantifying the changes in the visual forms from one retention test to another. With words and stories, the difficulty is that there is no independent measure of the personal meaning of the words or stories themselves. As a result there is no reference point from which any variety of organization could be measured. Unless a prior criterion for organization of the stimulus material is set up, it is unlikely that there will be a referent with which to assess organization in the responses. As it has been indicated at the outset, the primary purpose of this paper is to report upon the application of Bousfield's method of analyzing the occurrence of clusters of related words in recall. By the use of this technique we will obtain a measure of one kind of organization in which the recall of material may occur; namely, the occurrence of related words. The use of the Bousfield technique satisfies the requirement that there be a quantitative method of measuring organization. By use of the method of successive retention tests, we seek to obtain data upon the changes in the organization of the words recalled.

METHOD²

Subjects. The subjects were 23 undergraduate students at the University of Connecticut.

Apparatus and Materials. A list of 60 stimulus words was employed. The words were chosen to represent the six values measured by the Allport-Vernon Study of Values (14). Thirty-six of the stimulus words were previously employed by Postman, Bruner and McGinnes (15). The additional 24 words were selected in the same manner as described in their study (op. cit., p. 143). Table 1 gives the stimulus words listed by value-category and the mean frequency of words in each value category obtained from the Thorndike-Lorge word list (16). Two separate lists of the 60 words were made up by use of a table of random numbers.

Procedure. The procedure employed here follows the one devised by Bousfield and Cohen (17). The words were projected twice in un-systematic order by means of a Keystone overhead projector. The rate of projection of the words was three-seconds per word. After presentation of one list there was a thirty-second pause before the second projection of the other list. Immediately after the second presentation, the Ss were told to start writing the words on the paper provided in the order in which they recalled them in accordance with instructions given before the words were shown. Ten minutes was allowed for each recall period.

There were three additional recall tests spaced one week apart. The E appeared at the same time one, two and three weeks after the first recall tests. He reminded the Ss of the experiment and asked them to recall as many words as they could. The instructions to write the words in the order in which they occurred to the Ss were repeated. After the last recall test, the E asked each S to write on his data sheet whether he had tried to recall the words during the time between tests. Six Ss, who indicated rehearsal, were not included in the analysis of the data.

Treatment of the Data. The analysis of the words recalled in terms of clusters involves classifying each word in one of the six Allport-Vernon categories. Each word was labelled according to its classification: i.e., T for theoretical; E for economic; A for aesthetic; S for social; P for political; R for religious; I for words which were illegible, or if legible did not belong to any of the six categories of the stimulus words. The symbol NL was added for words belonging to one of the six categories but not appearing in the stimulus words. The I-words and the NL-words identify two types of errors according to Bousfield and Cohen: the I-words are called irrelevant intrusions; and, the NL-words are called categorical intrusions. When the words recalled are classified according to the foregoing conventions, all sequences of two or more words in the same category (including the NL-words) constitute a cluster. Bousfield and Cohen (17) note the following regarding the NL-words:

It may be noted that our designation of clustering makes no distinction between "correct" responses and categorical intrusions. This follows from our operational definition of a cluster as a sequence of words identifiable as belonging to the same category (op. cit., p. 5).

Table 1

List of Stimulus-Words

Theoretical			Economic			Aesthetic			Social			Political			Religious		
Word	Freq.		Word	Freq.		Word	Freq.		Word	Freq.		Word	Freq.		Word	Freq.	
Prove	100		Industry	100		Beauty	100		Familiar	50		Control	100		Faith	50	
Science	50		Commerce	50		Artist	50		Friendly	50		Famous	100		Prayer	50	
Theory	50		Economic	50		Delicate	43		Kindly	50		Ruling	100		Religion	50	
Inquiry	22		Useful	50		Musical	39		Cordial	15		Citizen	50		Worship	50	
Research	22		Income	46		Literary	33		Helpful	14		Govern	39		Sacred	38	
Confirm	20		Finance	35		Ornament	30		Loving	12		Politico	25		Spiritual	21	
Analysis	14		Wealthy	27		Poetry	26		Genial	9		Compete	11		Blessed	6	
Logical	9		Utility	12		Graceful	19		Amiable	8		Dominate	11		Piety	6	
Verify	6		Monetary	4		Exquisite	16		Devoted	7		Eminent	11		Reverent	2	
Validate	2		Opulent	1		Elegant	13		Sociable	3		Illustrious	10		Venerate	1	
Mean Freq.	29.5			37.5			36.9			21.8			45.7			27.4	

The amount of clustering was calculated for each of the four tests of retention. For a six category list of words, the index of cluster (symbolized IR by Bousfield and Cohen) is:

$$IR = \frac{6r}{\sqrt{5n}} - \frac{\sqrt{n}}{5} \quad (1)$$

It should be noted that the index of clustering is the critical ratio of the proportion of repetition for the six category stimulus list. It is:

$$CR = \frac{r - \frac{n}{6}}{\sqrt{n \frac{1}{6} \frac{5}{6}}} \quad (2)$$

The term r in both formulas is the total number of repetitions of words from the same category. The term n is the total number of words recalled minus one. The index of clustering was calculated for each S for each of the retention tests.

RESULTS

Organization of Recall (As measured by the Index of Clustering) For the Four Retention Tests. The mean amount of clustering and the P value of the mean amount of clustering as a chance departure from zero clustering is found in table 2. All four retention tests show a reliable amount of clustering albeit accompanied by a considerable amount of variability. If we take the index of clustering as the measure of the organization of recall, these results indicate that the amount of organization of the L- and NL- was reliable. Table 2 indicates that after the drop in clustering in the second retention test, there is a progressive increase in the mean amount of clustering until the fourth retention test.

Number of Words Recalled in Four Retention Tests and the Percentage Loss of Original Learning. Table 3 shows the number of words recalled for each of the four retention tests in the categories Listed and Not-Listed words. Here also, the percentage of loss of the listed words, and the percentage of gain of the NL-words is given. The amount recalled in the first retention test has been taken as the measure of original learning. In table 3, the percentage change in L-words and NL-words after the first retention test is taken as greater than or less than 100 percent. These results indicate that the loss of listed words becomes stabilized after the second retention test. In general, these findings corroborate the finding by Bousfield and Cohen that the amount of clustering is a function, in part, of the number of words recalled. It is noteworthy that the relative gain of the NL-words is greater than the gain of the listed words after the second retention test. A comparison of the decrease in the percentage loss of the listed words with the percentage gain of the NL-words also

Table 2

Clustering (IR scores) for
Four repeated Recall Tests (N 23)

Retention Test	Mean	Sigma	P
1	1.80	1.62	.01
2	0.99	1.38	.01
3	1.76	1.56	.01
4	2.03	1.55	.01

Table 3
Number of Words Recalled and Percentage
of Original Learning

Retention Test	Listed Words	% Change in L-Words	NL- Words	% Change in NL-Words	I- Words	Total
1	504	(100)*	36	(100)*	31	571
2	276	55	77	114	61	414
3	292	42	93	158	83	468
4	295	41	94	161	78	467

* Retention test 1 is taken as the measure of original learning,
and given the reference value of 100%.

indicates the same thing. In other words, the increase in the number of words recalled is mainly due to recruiting new words to the six value categories.

The Analysis of Variance of the Percentage of Repetition. The findings on changes in organization as analyzed by the method of cluster analysis raises two questions. The first is in connection with the use of the critical ratio of the proportion of repetition as a measure of organization. Since the magnitude of the critical ratio is a function of the n of the standard error of the proportion, there is a bias in the index of clustering. Sakoda and Cohen (18) have shown that the percentage of repetition of words from a given category ($r/n \times 100$) is correlated with the number of words recalled but that the percentage of repetition is not correlated with the total number of words recalled in a retention list. Therefore, if the percentage of repetition scores were employed rather than the index of clustering an unbiased estimate of organization would be obtained. Secondly, having found that there is a reliable amount of organization in the recall of the words, and that changes in organization occur over the four retention tests, what are the major sources of variance? To answer these questions a triple classification analysis of variance was performed on the percentage of repetition scores. These scores were obtained by dividing the number of repeated words for a given category minus one by the number of listed and NL-words for the given category, and then multiplying the proportion by one hundred ($r/n \times 100$). This was done for each S, for each of the six categories and for each of the four retention tests. Thereby, the three main effects of the analysis of variance are Ss, categories and retention tests. Since the standard deviation of a percentage tends to be proportional to the size of the percentage, the percentage of repetition score was transformed to arcsin values.

Table 4 gives the results of the analysis of variance. Each of the three main effects, Category, Retention tests and Individual Differences (Ss) has an F-ratio the probability of whose occurrence is considerably less than .01. Among the first order interactions, the Ss X Category is the only significant one. The triple interaction was the error term in obtaining the F-ratio for the effect due to the Retention tests. Since this effect does not enter reliably into an interaction with the other effects, the significant F-ratio indicates that the four retention tests independently influences the percentage of repetition. The error term used to test the significance of the F-ratio for the Categories and for the Ss was the significant interaction variance of the Ss X Category. The use of this first order interaction term was made on the assumption that our Ss were not chosen in any systematic fashion. From these findings we can conclude that the differences between individuals in the percentage of repetition is in part dependent upon the differential retention of words and recruiting of words from the value-categories. Similarly, the differences in the percentage of repetition between value-categories is in part due to the differential selection of categories by the Ss.

Table 4
Analysis of Variance of Percentage of
Repetition Scores (transformed to Arcsin Values)

Source	Sum Squares	df	Variance	F	P
Category (6)	29,611.44	5	5,922.29	7.74	.01*
Retention Tests (4)	4,471.27	3	1,490.42	6.17	.01*
Individuals (23)	38,916.76	22	1,768.94	2.31	.01
Individuals X Value- Category	84,220.24	110	765.64	3.17	.01
Individuals X Retention Tests	19,468.76	66	294.98		NS
Retention Tests X Value Category	1,362.80	15	90.85		NS
Triple Interaction	79,711.34	330	241.54		
Total	257,762.61	551			

* Error term is the interaction: Individuals X Value-Category. For the remaining F ratios the triple interaction is the error term.

A comparison of the changes in the percentage of repetition with the changes in the index of clustering over the four retention tests is found in table 5. The pattern of changes obtained with each measure is about the same; i.e., the drop in the second retention test, and the progressive increase in the third and the fourth retention tests. In general, these findings confirm that the recollection of a stimulus list of unsystematically arranged words becomes organized when the recollection is tested. And, upon further retention tests, there are changes in the organization of what is recalled as well as changes in the number of words recalled. The changes in the organization of the recall are in the direction of increasing organization. Whether a maxima had been reached was not investigated. The number of listed words recalled increases, and the number of NL-words recruited increases with successive retention tests.

DISCUSSION

(1) The first question raised at the outset was the application of Bousfield's method of analyzing clusters to the problem of changes in the organization of retention. Our findings indicate that such an analysis is possible if one accepts the definition of organization as the occurrence of sequences of related words in recall. While it is more efficient to employ the percentage of repetition score rather than the index of clustering as the measure of organization, the findings with both procedures are substantially the same (see table 5). It is important to note, however, that neither of these measures of organization are the sort of organization which classical Gestalt theory deals with. In Gestalt theory, a variety of organization occurs because of the structural properties of the stimulus and because of the properties of the brain field. Since the unsystematic arrangement of our list of words intentionally minimizes 'structure' in the stimulus, the organization obtained here is more likely a measure of the 'functional' properties of the stimuli (19). Thus, the organization of the recalled words is a consequence of personal or social significance of the clustered words. For this present study, it would be more appropriate to invoke a theory of remembering like Bartlett's or Hebb's.

(2) The findings on clustering and on the words retained and recruited suggest a relationship between retention and organization. Table 5 indicates that clustering and the number of listed words drop markedly in the second retention test. In contrast, the NL-words increase more than twofold. But, after the second retention test, both clustering and the number of words recalled (L-words) and recruited (NL-words) increases. A tentative explanation of this is that the degree of organization is dependent upon the set of the Ss to recall the words. No indication had been given the Ss that there would be additional recall tests after the first one. And so the loss in the second retention test is just about the decrement in retention one would expect. But, after the second retention test, it may have occurred to the Ss that further retention tests would take place; i.e., they expected further retention tests. Here a relationship between decrements in retention and the organization of the

Table 5

Organization of Recall Measured by the Index of Clustering
And the Percentage of Repetition

Retention Test	IR	Percent Repetition	NL- Words	Listed Words
1	1.80	27	36	504
2	0.99	20	77	276
3	1.76	26	93	292
4	2.03	27	94	295

retained material is indicated. If the only effect of successive retention tests is to increase the probability that words already recalled will be recalled again, we would expect the increase in the listed words recalled to be greater than the NL-words on retention tests following the second retention test. This is not the finding obtained here. From the second to the third retention tests, the gain of the listed words is 13 percent, while the gain of the NL-words is 34 percent. If, alternatively, an effect of successive retention tests is to increase the organization of the original list of words, then more NL-words would occur than listed words. This would follow if organization is analogous to a schema (20), or a superordinate structure into which single items fit. In other words, the organizing process (whatever it is) functions not only to keep together things which go together but also to recruit additional similar items. Thus, instead of the usual decrement in retention taking place, one would expect the organization to hold up the decay. So one finds in the third retention test and also in the fourth retention test that the number of listed and NL-words recalled becomes greater.

Obviously, the tenability of the foregoing interpretation requires more empirical evidence on the influence of set, and practice between retention tests on organization and on the number of listed and NL-words recalled.

(3) The analysis of variance of the percentage of repetition scores (table 4) gives some support to the explanation offered above. The Ss X Category interaction is significant. This indicates that the Ss were selecting words differentially from the six value-categories. That is, there was a differential recollection of words by individuals who differed with regard to their category preferences. This occurred independently of the four retention tests. A hypothesis which may be offered is that the effect of the category preferences upon retention is to increase the probability of recalling words which belong to the preferred categories. Since words from preferred categories have a high probability of occurrence, it also seems likely that these words would tend to occur together in recall. Or alternatively, as it has been defined here, the effect of preferred words is to produce clustering. If the Ss had responded unsystematically, albeit differently, then none of the interactions would have been significant. All one could have said, if such an event had occurred, is that successive retention tests increases the probability that certain words would occur. That is, practice merely makes it more probable that words already recalled will be recalled again. Instead, the analysis of variance indicates that the effect of the successive retention tests is to increase the probability that an idiosyncratic organization of the recalled words will occur upon subsequent retention tests. We suggest, tentatively, the effect of this organization is to reduce the loss of words recalled at first, and to recruit words not appearing on the stimulus list but fitting into the organization of the recalled words.

SUMMARY

The purpose of the present study was to apply Bousfield's method of analyzing the occurrence of clusters of words in recall to the temporal changes in the organization of recall. Organization or clustering was defined as the occurrence of sequences of words in the same category. A list of 60 words, ten words representing each of the six Allport-Vernon personal value-categories, was used. The list was presented in two different unsystematic orders to a group of 23 Ss. Immediately after the two presentations, and subsequently one week, two weeks and three weeks later, ten minute retention tests were given.

The analysis of the data showed the following:

1. There was a reliable amount of clustering during each of the four retention tests.
2. Over the four retention tests, there is a trend toward increasing amounts of clustering. At the second retention test, however, there is a marked drop of the amount of clustering. Clustering increases at the third retention test and continues to increase at the fourth retention test (reaching a level higher than at the first retention test).
3. The number of words recalled from the stimulus list follows the same trend as the clustering. Not listed words, but words classified as belonging to one of the six categories, increase progressively with each retention test.
4. An analysis of variance indicates that different Ss select words from each category differentially. There is, however, no reliable interaction between Ss and Retention tests, and between Categories and Retention tests. Thus, the retention tests influence clustering independently.

It is concluded:

1. Bousfield's method provides a means for quantifying the temporal changes in the organization of the recall of words.
2. The inversion of the amount of clustering and the number of listed words recalled indicates that the set of the Ss influences the occurrence of clustering.
3. Individual differences in value-category preference may account for the kinds of words which are clustered.
4. The occurrence of clustering (or organization) may retard the forgetting of words retained at the first exposure of the stimulus list.

FOOTNOTES

1. I am indebted to Dr. David Zeaman for suggesting this alternative explanation.
2. I wish to express my appreciation to Dr. W. A. Bousfield, J. Sakoda and D. Zeaman for their critical comments.
3. The amount of clustering, in general, is a function of the number of words recalled. This can be a statistical artifact since in formula (2), the magnitude of the critical ratio of the proportion is, in part, a function of the number of words recalled.

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